Social Network Analysis on Grain Production in the Brazilian Scenario

Lúcio Costabile, Oduvaldo Vendrametto, Geraldo Oliveira Neto, Mario Neto, Marcelo Shibuya

Social network analysis on grain production in the Brazilian scenario

Lúcio T. Costabile[1], Oduvaldo Vendrametto[1], Geraldo Cardoso de Oliveira Neto[2], Mario Mollo Neto[3] Marcelo K. Shibuya[1]

[1]Paulista University-UNIP, Graduate Program in Production Engineering, Dr. Bacelar St. 1212, São Paulo, Brazil
[2]Nove de Julho University - UNINOVE, Graduate Program in Production Engineering, Francisco Matarazzo Avenue, 612, São Paulo, Brazil
[3]São Paulo State University "Júlio de Mesquita Filho", Tupã, São Paulo.University-UNINOVE, Graduate Program in Production Engineering, Francisco Matarazzo Avenue, 612, São Paulo, Brazil
{Lucio Tadeu Costabile, luciotc@terra.com.br}

Abstract. This article provides study of the 2012/2013 grain harvest of federal units of Brazil in relation to the following factors: planted areas, productivity, and production, which assist producers in agricultural planning. The research method used for data collection was the documentary and exploratory data analysis using the software Ucinet® for social networks. The findings indicate that the Midwest has the largest area planted in soybean per thousand / ha, demonstrating the opportunity for producers to develop new crops. In production in thousand / ton, the Midwest region also excelled in soybeans, showing the possibility for producers to seek new techniques for planting. The southern has the highest productivity of the rice grain per kg / ha, contributing to the producer having the best land use and resource optimization.
Keywords: Network Analysis, Centrality, Grains, Geographic Regions.

1 Introduction

Brazil is one of the largest economies in the world and in this context contributes significantly to agribusiness, standing as one of the largest producers and exporters of grain. With the advance of incentives, the country's agriculture has been increasing in the production and export of grains, mainly soybeans, corn, rice [1, 2] and wheat [3]. The country's federal units have undergone changes in recent years. Factors such as the emergence of new technologies, research development, and new planting techniques have emerged [3]. In this context, it is necessary to plan agricultural production, considering the use of machinery and equipment and manpower for operation [4]. The soybean is one of the agricultural products with highest production and participation in Brazilian agriculture [5]. Rice production provides satisfactory results in the Brazilian agribusiness, due to the cultivation of rice [6] and adoption of new techniques and specialized machinery [7]. On the production of corn, Brazil ranked

third, as a major exporter [8]. Regarding the wheat crop, production exceeded expectations for planted area, resulting in a reduction in imports [3].

A literature search on grain production in Brazil found the need of agricultural production planning to minimize risk and achieve better financial return [4]. In this context, it is necessary to invest in new technologies to provide the development of new techniques in the Brazilian agricultural sector. These new technologies include, for example, the study of geographic variables (soil, atmosphere, and temperature) of each region to improve handling and increase productivity [5], intensification of technologies for a grain storage process to reduce loss [9], introduction of incremental changes in rice planting to contribute to increased productivity [6], and the analysis of the influence of rice as the ability to influence [7] the economy of a region. There was a lack of research related to social network analysis at a national level to measure the relationship between the network actors (regions and types of grains) to assist the producer in the planning of agricultural production. The analysis included data extracted from the following variables: areas planted per hectare, yield, and production [10]. In this context, for effectiveness in grain production, new forms of agricultural planning can be performed based on the centrality of the network, i.e., other technological applications in terms of resources and enhancement techniques can be employed in regions with the highest centrality. The degree of centrality measures the number of links between actors in the network, allowing inclusion of the strategic position of each actor [11]. From this emerged the following research question, which grain has the greatest impact on Brazilian Agriculture in relation to the planted area, yield per hectare, and production per ton? To answer this question, we chose to analyze Social Networks. These structures can be defined by the reciprocal relationship between independent, but economically interdependent, agents, aimed at cooperation to achieve common or complementary goals [12, 13, 14]. The structure of the network and the position of the actors can affect the functions of the organization and their skills in generating value [15]. Connectivity, which is the ability to link each individual network, can be represented by the intensity and frequency of communication between the actors [16]. The most common representations of networks are those in which the nodes represent actors and ties, allowing transfer of information [17]. We can classify the links / bonds by their intensity, denoting absent, weak, and strong ties [18].

Thinking of the research question, this study aims to assess which of the grains and regions of the 2012/2013 harvest had greater impact on the Brazilian agribusiness in relation to the acreage productivity per hectare and production per ton. This can help producers with agricultural planning and will present the factors that influence the culture of grains. Our assessment was done using Ucinet®. By applying network analysis with relational matrices, and the visual analysis of graphs of these same networks, it allowed the finding of new indicators, other than those offered by traditional statistical analysis with specific focus on the degree of centrality.

2 Methodology

This article presents an exploratory research study through a literature review using the keywords: grain production and agribusiness, in databases: Science Direct,

Proquest, Ebsco, Capes, and Scielo. Data collection was conducted through research in a regulatory government agency of the Brazilian agricultural sector called the National Supply Company (Companhia Nacional de Abastecimento - Conab). Using these sources, we mapped the crops of grains under study for a period related to the cultivated area, including yield per hectare and production in thousand tons, for the harvest of 2012/2013 in the federal units of Brazil, as shown in Table 1.

Table 1. Mapping of crop – planted area, production and productivity

Federal Units	Planted area - million hectares (mm/ha)				Production - thousands of tons (m/t)				Productivity - kilogram per hectare (kg/ha)			
	Soybean	Corn	Rice	Wheat	Soybean	Corn	Rice	Wheat	Soybean	Corn	Rice	Wheat
North	833	560	320	0	2537	1624	965	0	3045	2898	3011	0
Northeast	2329	2450	604	0	6915	5375	1043	0	2696	2194	1727	0
South	9604	4438	1238	1817	28705	24699	9125	4245	2989	5565	7369	2336
Southeast	1735	2178	45	53	5080	12274	135	162	2828	5633	3002	3036
Midwest	12738	5133	201	24	39389	27962	658	68	3092	5447	3269	2750

Source: CONAB, (2012/2013)

For the creation of the crop mapping, we used matrix and graphical analysis of the data provided to look at the relationship between the individuals in the network. For this, we used social network analysis software (Ucinet®), developed in the laboratories Analytic Technologies at the University of Greenwich. This methodology allows the mapping of networks of federal units with the respective values of area, yield, and production per hectare.

The values obtained from literature surveys are included in generated files in the Windows operating system notepad, thus building the files of type ".vna" (visual network analysis) required for implementation and enforcement in Ucinet® software. The processes result in the values of the degree of centrality of interaction of the actors within the network [19].

The general degree of centrality is composed of the input degree of centrality and by the output degree of centrality, and these depend on the relative direction of flow. The sum of relations that an actor has with other actors is the output degree centrality, and the sum of relations that the other actors have with a particular actor is the input degree of centrality [20]. An actor is locally central, if it has a large number of connections to other points. It is globally central, if it has a significant strategic position in the network as a whole [11]. The centrality of degree is measured by the number of ties that an actor has with other actors in a network [21].

Generally, for software available for network analysis, as used in this research with the Ucinet® and Netdraw® module, the data is provided by relational matrices (socio-matrices in the language of sociologists), which can be viewed through graphs. The graphic display alone can offer new information and insights for researchers [22, 21]. This function was used via the Netdraw® module accompanying Ucinet® to enable the visualization of networks based on the ".vna" files generated.

The corresponding graphs of Planted area networks, Productivity, and Production, are generated with Netdraw®, and the images obtained are marked by relationships of higher intensities and their respective directions. Likewise the actors are indicated (highlighted with discs in red) with its expanded size (larger diameter)

based on their relative centrality, in order to visually indicate the actors with greater power or influence, and participation in the network by means of larger diameter.

The design of centralities in accordance with the indications [23], obeyed the software, application of the following equation 1:

$$C_G(v_k) = \sum_{j=1}^{n} w_{kj} \quad \text{Eq. 1}$$

Where:

C_G = Degree of centrality;

v_k = Node of the net to be considered;

j = Number of nodes;

w_{kj} = Number of adjacent nodes;

and, $w_{kj} = 1$ if there is a link between the nodes *vk* e *vj*.

After visualizing the data for analysis and the corresponding graphical behavior in the networks under study, it is possible to obtain the patterns of the actor's behavior and to transcribe this data to relational matrices (also known as sociometric matrices), which are necessary for the data analysis by the chosen analysis program, Ucinet®.

3 Results and Discussion

After data entry, the actors were processed using UCINET® software. The data represents areas planted in million hectares, productivity in kilograms per hectare, and production in thousands of tons of soybeans, corn, rice and wheat, in the Brazilian states of the Midwest, South, Northeast, Southeast, and North, and their relationships, represented by the values of participation of each grain which resulted in the interaction of the actors within the network.

Planted area

The graph of the corresponding network acreage was developed in Netdraw® (Figure 1) and it shows the centrality of the network and the positional indicators and intermediary actors. The results indicate that the Midwest and South regions have the highest densities (or most significant trade links) between the actors in the network, i.e., greater participation among the federal units in areas planted on millions of acres, confirming what was collected in the literature review, with 12,738 million/ha of soybeans planted in these areas, 5,133 million / ha of maize, 201,000/ha of rice, and 24,000/ha of wheat. Soy has the highest centrality in the relationship, due to new technologies, research development, and economic changes in the [4] region. On the international scene, Brazil appears as the largest soybean supplier to China and the United States.

The results obtained by Ucinet® found that the OutDegree is the level of output, representing the share of each federal unit. The Midwest revealed 18,096 million hectares of planted areas; followed by the southern region, with 17,097; the Northeast, 5,383; Southeast: 4,011; and North, 1,713. The InDegree represents the degree of entry, or the quantities of areas planted with beans with their respective values in million hectares, considering all regions, resulting in soybeans for 27,239; corn, 14,759; rice, 2,408; and wheat, 1,894. The actor "soy" has the highest degree of entry,

with the Midwest region 12,738,000 / ha, Southeast 1,735 million / ha, South 9,604,000 / ha, Northeast 2,329 million / ha, and North 833,000 / ha, totaling 27,239 million hectares. The highlight is the Midwest region, which has the highest level of output, i.e., is the main actor who has the highest participation of areas planted in million hectares in the country. This share is characterized due to research for adaptation of new crops for fertile soils, such as cotton, soybean, wheat, corn, etc. [5]. It is noteworthy that the increase of planted areas is due to the new planting techniques, improved communications, and the significant consumer market in the Southeast region, which has contributed to the increase in commercial agriculture development [5].

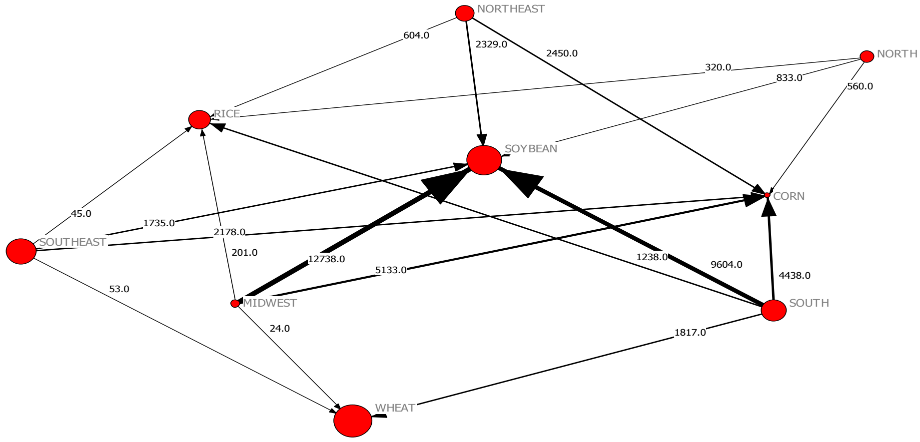

Figure 1. Representation of the corresponding network acreage, crops, and regions represented by Ucinet® software and its Netdraw® module.

We found that the average degree of centrality of the relationship between the actors of the network was measured at 14,298% for output values, and 24,392% for the input values, which indicates that power is distributed over the network heterogeneously both for input relationships and output relationships.

The values obtained also show that the Midwest has the largest area of planted areas in million hectares, and the prospect is that the Midwest will continue to invest in increasing planted areas, mainly in soybean cultivation, which showed growth during the last three decades.

Production

The results obtained by Ucinet® (Figure 2) in OutDegree, found that the Midwest was the most substantial at 68,077,000 / t, followed by the southern region, with 66,774,000 / t, Northeast: 13,333,000 / t; Southeast: 17,651,000 / t, and North: 5.126 million / t. The results show that the Midwest and South, have the highest levels of output and are the main actors who have higher productions thousand / t and have more developed techniques for planting, which can be studied by the regions with the lowest rate of production. These techniques were presented [7] regarding the different soil types, climate, availability of water for agriculture, land use, and technological resources that contribute to increase production. The research [4] also mentions that the South has great genetic potential of new forms of cultivation, producing satisfactory levels of commercialization, directly impacting the profitability of agribusiness.

The actors' (representing the grain) InDegree accounted for soybeans: 82,626, corn: 71,934, rice: 11,926, and wheat: 4,475. Soy has the highest degree of entry, most notably in the Midwest: 39,389,000/t; South: 28,705,000/t; Northeast: 6,915 million/t; Southeast: 5,080.000/t; and North: 2,537,000/t, for a total production of 82,626 million/t. General indicators of the network and their descriptive statistics related to the production per thousand / t denoted the state of network centrality output was measured as 17,523%, and the degree of input centrality was 22,717%.

These figures show that power is distributed over the network heterogeneously both for input relationships and output relationships. However, with regard to the levels of output, it is observed that there is a higher concentration to the power of the regions center -west and south, which are, as highlighted earlier, the largest producers. But, one should also highlight, the areas are very disparate from each other as well as the productivity of the regions focused on in the study.

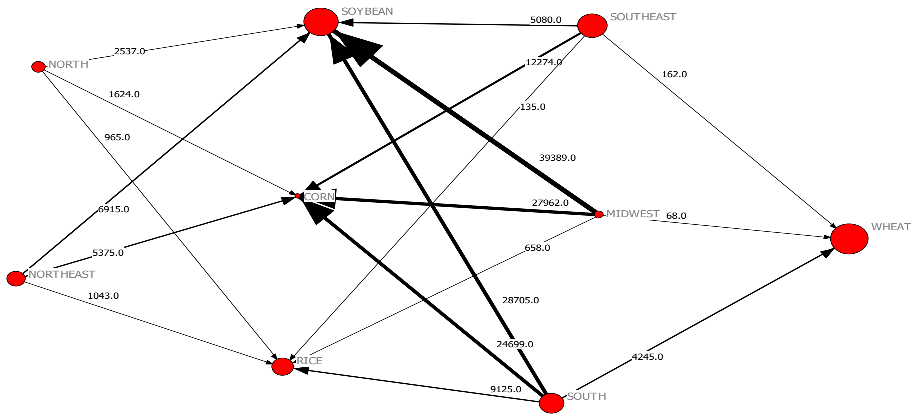

Figure 2. Representation of the corresponding network production, cultures and regions represented by Ucinet® software.

Productivity

In Figure 3, using calculations applying the processing with the software, the results indicate via the analysis of OutDegree, that the southern region has the highest level of output (18,259 kg/ha), followed by the Southeast (14,599 kg/ha), Midwest (14,558 kg/ha), North (8954 kg/ha) and Northeast (6617 kg/ha). It is noteworthy that in the South, the rice grain represents the largest production (7,369,000/t), followed by maize (5565 kg/ha), soybean (2989 kg/ha) and wheat (2336 kg/ha). In relation to InDegree analysis, we found that corn grain is the most representative (21,737 kg/ha), followed by rice (18,378 kg/ha), soybean (14,750 kg/ha) and wheat (8122 kg/ha). This finding is corroborated by [4] due to favorable conditions for growing. The southern region has attracted several companies in the agribusiness sector for research, use of new technologies, and new inputs correcting soil deficiencies for planting.

The degree of overall centrality of network output was measured in 21,489% and the degree of input centrality was 28,126%. The figures show that the network has low power relations between the actors in the case of the degrees of output, which indicates that there is no balanced participation of regions for the production as a whole. This can be seen in the lower contribution of North and Northeast. However, the

product that stood out in this case was the highest input degree of centrality, the corn, and its production was strongly influenced by good production in all federal units participating in the study.

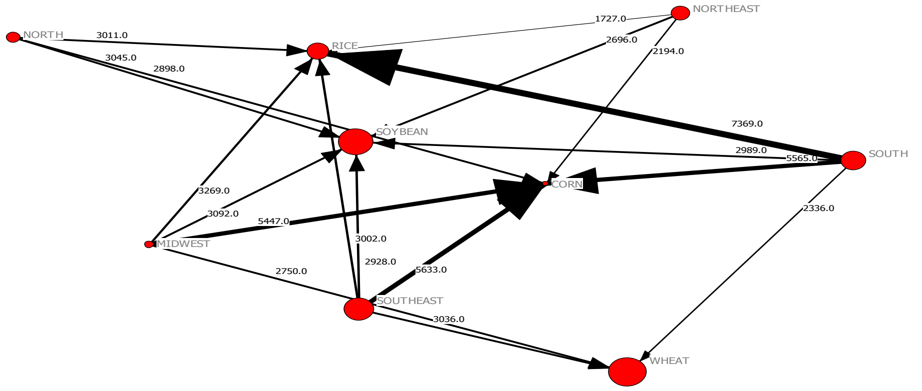

Figure 3. Representation of the corresponding network productivity, cultures and regions represented by Ucinet® software.

The largest production in thousands of ton was presented in the South concerning the growth of planted areas, alternative crops, adoption of new management systems appropriate to the soil, use of technology, tax breaks, and donations of new land for planting. This stands out because the participating regions provide areas with large differences in their size and production per ton varies greatly between states.

7 Conclusions

With the use of the social network analysis technique, we found that the Midwest region showed the highest share of areas planted in million hectares in the country, followed by the South region, with the soybean receiving the largest investment, and presenting the largest participation in the growth of cultivated areas. This analysis can help producers based on cultivating the soil with the help of research and new techniques of planting, as well as new forms of financing. For example, the producers of the region with the lowest degree of centrality (North) could develop new crops in the region.

The Midwest region was found to have the highest production in thousand / t, followed by the South, with the largest share of soybeans, corn, and rice, because of the resources used in cultivation. In pursuit of increased production, this result will allow direct producers to better understand the planting techniques. For example, regions with lower production volume can intensify these factors to increase their crops.

The southern region aims to be the leading region with higher grain yield kg / ha, with the emphasis on the grains of rice and corn, taking advantage of climate conditions, and human and technological resources of the region. The results indicate to producers the need for better use of soil, seed selection, and the best use of natural resources in the region, because with this, other regions could contribute to the grain productivity at a national level. For example, the Midwest, the leader in planted areas

and production, is not the most important in productivity per hectare, indicating that the increase in productivity is related to better land use and resource optimization, leading to better crop yield. A limitation of this research is the use of a documentary exploratory research approach. For future research regions with less centrality could be explored to propose new incentives and agricultural practices to increase productivity.

References

1. Wto. (2008). Trade policy review. Available on: <http://www.wto.org/english/tratope/tpre/s212-04e.doc> accessed in: November 08th.
2. Usda. (2013). United States Department of Agriculture. Production, Supply and Distribution. Available on<www.fas.usda.gov/psdonline> accessed in: March 06th.
3. Conab. (2006). Companhia Nacional de Abastecimento. Situação da Armazenagem no Brasil. Available in:<www.conab.gov.br> accessed in: April 10th.
4. Osaki, M., Batalha, M.O.: Optimization model of agricultural production system in grain farms under risk, in Sorriso, Brazil. Agricultural Systems 127, 178–188 (2014).
5. Pontes, H. L. J., Carmo, B. B. T., Porto, A. J. V.: Problemas Logísticos na Exportação Brasileira da soja em grão. *Revista Eletrônica Sistemas & Gestão*. Niterói 4, 155-181 (2012).
6. Nitzke, J. A., Biedrzicki, A. (2012): Terra de Arroz. Available on: <http://www.ufrgs.br/Alimentus/terradearroz/producao/pd_ecossistemas_sim.htm> accessed in February 08th.
7. Vieira, A. C. P., Bruch, K. L., Watanabe. M., Yamaguchi C., K., Neto, R. J., Bolson, E. A.: A influência das inovações no campo: as cultivares produzidas na Região Sul Catarinense no Brasil. Revista Espacios 33 (2012).
8. Ferraz, J. P. S., Felício, P. E.: Production Systems – An example from Brazil. Journal Meat Science 84, 238-243 (2010).
9. Tefera, T., Kananpiu, F., Groote, H., Hellin, J., Mugo, S., Kimenju, S., Beyene, Y., Boddupalli, P. M., Shiferaw, B., Banziger, M.: The metal silo: An effective grain storage technology for reducing post-harvest insect and pathogen losses in maize while improving smallholder farmers' food security in developing countries. CropProtection 30, 240-245 (2011).
10. Conab. (2014). Companhia Nacional de Abastecimento. Acompanhamento da Safra Brasileira – Grãos 2012/13, Available in:<www.conab.gov.br> accessed in: March 10th.
11. Scott, J.: Social network analysis: Sage Publications (2000).
12. Powwel, W.: Neither market not hierarchy: network forms of organization. Research in Organization Behavior 12, 295-336 (1990)
13. Williams, T.: Cooperation by design: structure and cooperation in inter organizational networks. Journal of Business Research 5.867, 1-9 (2002).
14. Borgatti, C. R.: A Social Network View of Organizational Learning. Management Science, 49, 432-445 (2003).
15. Lazzarini, S. G.: Empresas em rede. São Paulo: Cengage Learning (2008).
16. Borgatti, C. R., Li, X.: On social network analysis in a supply chain context. Journal of Supply Chain Management 45 (2009).
17. Krackhardt, D., Hanson, J. R.: Informal networks: the company behind the chart. Harvard Business Review 4, 104-111 (1993).
18. Granovetter, M.: Getting a Job**:** a study of contacts and careers. Second Edition. Chicago IL: University of Chicago Press (1995).
19. Borgatti, S. P., Everett**,** M. G., Freeman, L. C**.:** Ucinet for Windows: software for social network analysis. Harvard, MA: Analytic Technologies (2002)
20. Velazquez, A. O. A., Aguilar, G. N.: Manual Introdutório à Análise de Redes Sociais – Medidas de Centralidade: Exemplos práticos com UCINET 6.109 e NetDraw 2.28. 2005. Available on: <http://www.aprende.com.pt/fotos/editor2/Manual%20ARS%20[Trad].pdf > accessed in: February 03th.
21. Wasserman, S., Faust, K.: Social network analysis: methods and applications. Cambridge University Press (1994).
22. Iacobucci, D.: Graphs and matrices. In: Wasserman; Faust (1994).
23. Emirbayer, M., Goodwin, J.: Network analysis, culture and the problem of agency. American Journal of Sociology 99, 1411-1454 (1994).